Novel Structures in Silver on Si(111)

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DMR 0203097

Objective: To understand atom manipulation at the atomic level, and to build nanostructures in self alignment processes.

Generally, during growth of metallic films on semiconductor surfaces, many factors contribute to three dimensional growth of islands on the surface. Traditionally, these three-dimensional islands have grown in a Stransky-Krastanov (one smooth layer followed by 3-D “wedding cake” islands) or Volmer-Weber (3-D islands directly on the substrate), or grow epitaxially (layer by layer) on the surface. Recently, in the Pb/Si(111) system, annealing of low temperature deposited films to 250 K has produced *flat topped* islands as tall as 11 atomic layers. We have found a similar growth during annealing to 400 K of films which have been grown epitaxially at 100 K. *Flat topped* islands up to 20 atomic layers in height have been produced (see figure). This growth is thought to be due to electronic effects from the confinement of conduction electrons (quantum size effects). This self alignment process is another possible way to manipulate atoms on the atomic scale for mass production of nanostructures.

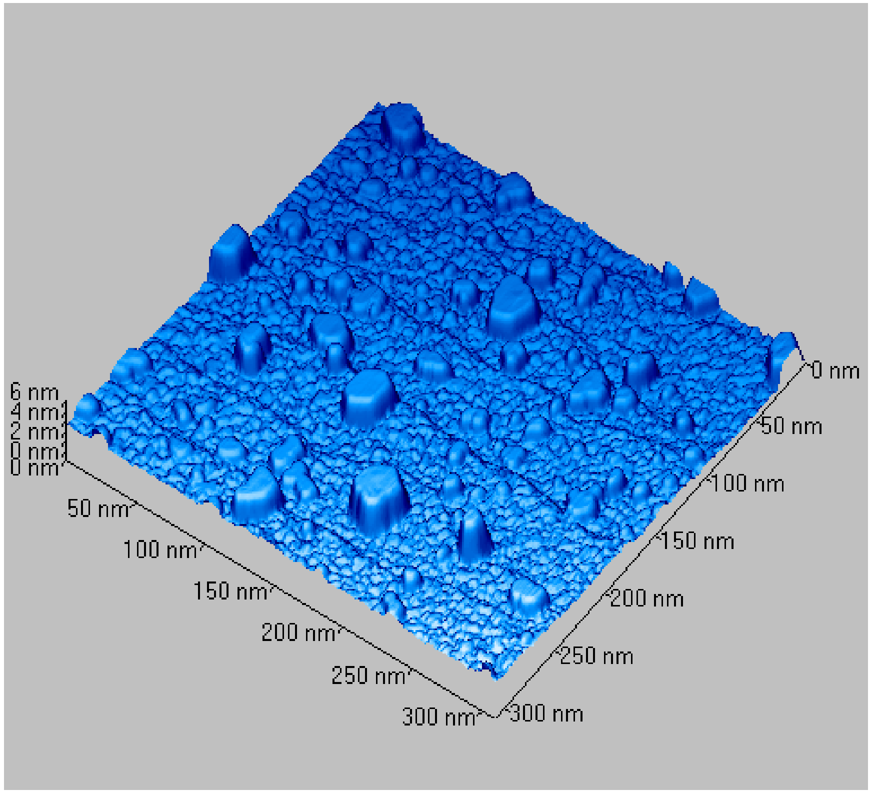

Figure 1. 1.1 ML of silver film deposited on Si(111) at 100 K followed by a 400 K anneal which produces flat topped islands of up to 20 atomic layers in height.

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This work involves the collaboration of two undergraduate physics majors, a senior named Steven Binz and a junior named Dan Ludois. Dan has worked the last semester on this project earning research credit, while Steven has worked the past year and worked in the summer internship provided for eight students in the physics department each summer. Steven worked with a Reflective High Energy Electron Diffraction (RHEED) system in the Ag/Si(111) system in the first summer in the internship program, and this past summer he worked on this project with the STM, becoming familiar with both techniques. This fall, he and Dan will analyze this data and present posters at national meetings such at the APS March Meeting in Los Angeles. There have been two other students, Greg Rutter and Laura Nagle, involved with the RHEED portion of this project, from construction of the system to presentation and publication of results.

Figure 1. Students Steven Binz and Dan Ludois assist Kevin Kimberlin in taking data on the Scanning Tunneling Microscope in the Bradley University Physics Department.

Electron irradiation of Diethylsilane adsorbed on Ge(100)

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•The objective of this work is to study the effects of electron irradiation of diethylsilane adsorbed on Ge(100) at 100 K.

• Silicon-germanium alloys are very important due to their applications in microtechnology. Diethylsilane (DES) is used to grow silicon on silicon substrates one layer at a time. The substrate is covered with DES and then heated up to over 900 K to remove carbon and leave only one fresh layer of silicon on the surface. The process by which carbon is removed from the silicon surface, shown in Fig. 1, on the left, is called β-hydride elimination. At 725 K, a hydrogen from the β position on the ethyl group is transferred to the surface and the carbon group leaves as ethylene. Then at 800 K, surface hydrogen leaves as molecular hydrogen. On germanium, the same process takes place, except that surface hydrogen desorbs at 570 K, then at 635 K, β-hydride elimination takes place. In our work, we found that if the DES-covered germanium surface is bombarded with electrons, enough silicon is deposited on the surface so that a double β -hydride elimination process occur, one from Ge and another one from Si, as shown in the graph. Furthermore, our data also indicated the possibility of electron-induced β-hydride elimination at 100 K.

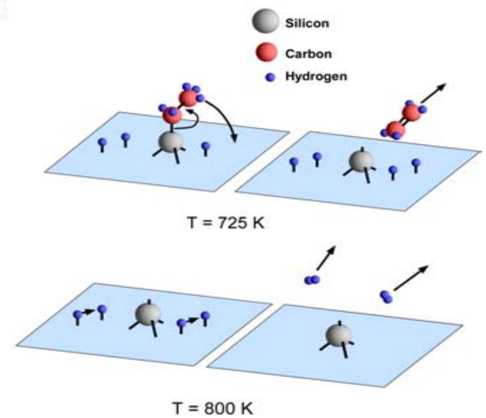

Fig. 1. Diagram showing β-hydride elimination process on a silicon substrate.

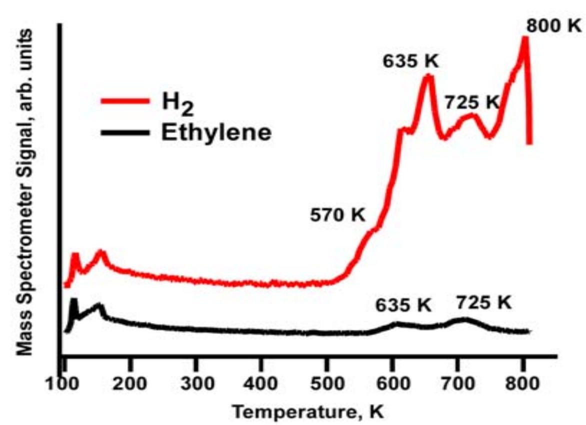

Fig. 2. Temperature programmed desorption from DES/Ge(100) after electron irradiation. The peaks at 570 K and 635 K result from β-hydride elimination on germanium. The peaks at 720 K and 800 K correspond to β-hydride elimination from surface silicon.

Electron induced decomposition of trimethylamine adsorbed on Si(100)

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Education:

This work involves the collaboration of two undergraduate students (Luke Bockewitz and Peter Petrany) and four physics research faculty members (Douglas Early, Kevin Kimberlin, Paul Wang, and James Craig, Jr.) Furthermore, the Undergraduate Research Summer Program, funded by the NSF, involves several undergraduate students in surface science and nanotechnology research. In the summer of 2004, eight undergraduate students participated in the program.

Dr. Lozano works with undergraduate students Luke Bockewitz and Peter Petrany on the HREELS system.